Activities at the Cranberry Research Farm: April to December, 2017

FINAL REPORT

Prepared for: Cranberry Research Farm (Grant Keefer and Todd May) and Cranberry Commission and Research Committee

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Objectives: The objectives of the fourth field season at the cranberry research farm were to continue to collect phenology and yield data on both newly released and numbered varieties from the Rutgers and Valley Corporation breeding programs. Additionally, trials were conducted for several different pest and crop management tools in Bogs 1, 3, and 4.

Activities: To achieve these objectives regular site visits were made to the research farm throughout the 2017 growing season (Table 1 and 2). Weekly site visits were also made by the E.S. Cropconsult crew for pest management monitoring.

Table 1. Summary of activities in Bog 1 (Planted with released and numbered varieties from the Rutgers University breeding program).

Date	Type of Activities	Specific information collected
June 7, 14, 21, 28	Data collection	% Bloom (to time fungicide applications)
June 11, June 26, July 5	Fungicide application	N/A
July 16	Fertilizer applications	N/A
August 25. September 21, and October 5	Berry collection	Yield
August 25	Sample collection	Foliage collection for foliar nutrient analysis
September 21	Berry Collection	Yield
August 18, 25, September 3, 13, October 18, November 7	Sample collection	Brix, TACY, ABS, Firmness (Bogs 1 and 2)
October 6	Berry Collection	Fungicide Trial Berry Harvest for Rot and Yield
November 7	Berry Collection	Brix and TACY for extended harvest

Table 2. Summary of activities in Bog 2 (Planted with released and numbered varieties from Rutgers University and Valley Corporation breeding programs).

Date	Type of Activities	Specific information collected
June 14	Planting	Rutgers Plots for CFIA Plant Breeder's Right Program
June 21	Planting	Willipa and BG plots
August 18, 25, September 3, 13, October 18, November 7	Sample collection	Brix, TACY, ABS, Firmness (Bogs 1 and 2)
September 21 and 22	Berry collection	Yield assessment

Table 3. Summary of activities in Bog 3 and 4 (Planted with locally-sourced Stevens in 2014).

Date	Type of Activities
April 27	Herbicide trials for moss control (Bog 4)
June 27	Gibberellic acid trials (Bog 3)

VARIETY EVALUATIONS

Methodology: Yield data were collected following the protocols developed and reported on in previous reports (see 2016 Final Report). Square-foot quadrats were placed randomly within the plot, ensuring that the location had 100% cranberry cover and no weeds. Berries were collected from Bog 1 on three dates: August 25, September 21 and one week prior to harvest on October 5. For Bog 1, berries were collected from three square-foot samples. Berries were collected from a selection of varieties in Bog 2 on September 21 and 22. Because variety trial plots are much smaller in Bog 2 only two square-foot samples were collected/plot. However, in Bog 2 there are two plots for each variety, so a total of four square-foot samples/variety. We collected a select number of varieties from the Rutgers 2013 planting, all of the Valley Corporation 2014 planting, and all of the Rutgers 2015 planting.

Results:

Bog 1 – Released Varieties – In 2017 the highest yielding cranberry variety was the numbered variety Rutgers Selection 25 (RS 25) with an estimated 532.48 barrels/acre (Fig. 1). Among the released varieties, the highest yields were observed with Welker (369.89 barrels/acre), followed by Crimson Queen (338.47 barrels/acre) (Fig. 1). These were the only three varieties with estimated yields exceeding 300 barrels/acre. The top yielding variety in 2016, Mullica Queen, had an estimated yield of 290.58 barrels/acre in 2017.

Overall, 2017 yields were lower for six of the varieties, but higher for three – including RS 25 and Welker (Fig. 2). For one of the varieties, Scarlet Knight, the three year trend is towards small increases in yield each year. The 2017 estimated yield for this variety was 237.1 barrels/acre. Two varieties – RS 69 and Haines - are showing downward trends over the past three years (Fig. 2). For Haines, in particular, 2017 was the first year that estimated yields were below 300 barrels/acre. However, the average estimated yield for Haines across all three years is 339.07 barrels/acre (Fig. 3).

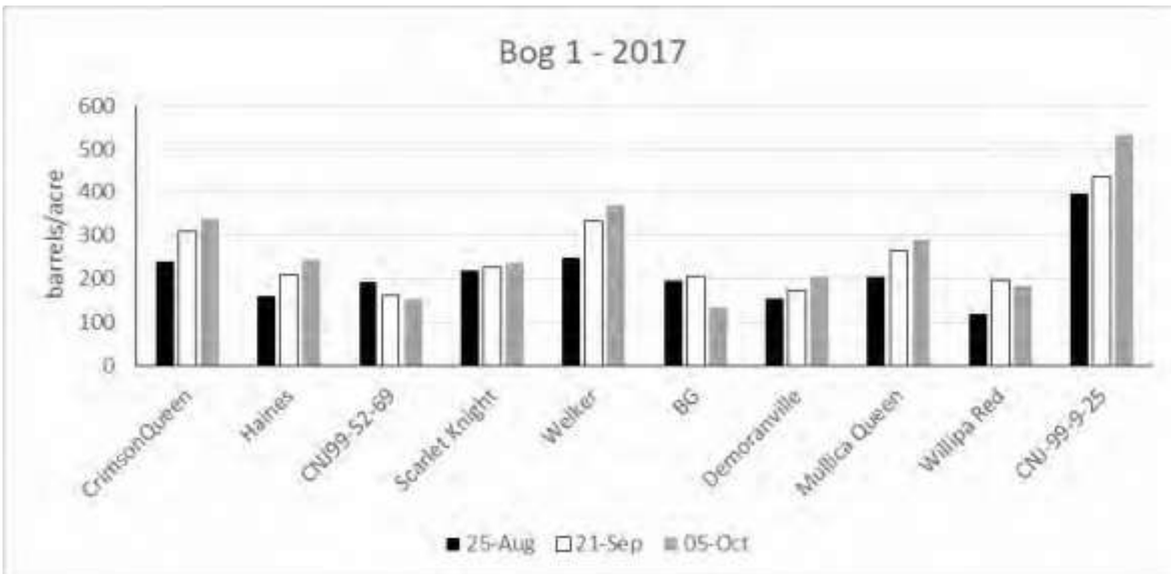

Figure 1. Estimated yields for 10 cranberry varieties grown at the BC Cranberry Research Farm, Bog 1. Data are for three collection dates in 2017. Each bar is an average, based on yield from three square-foot plots hand harvested from each variety.

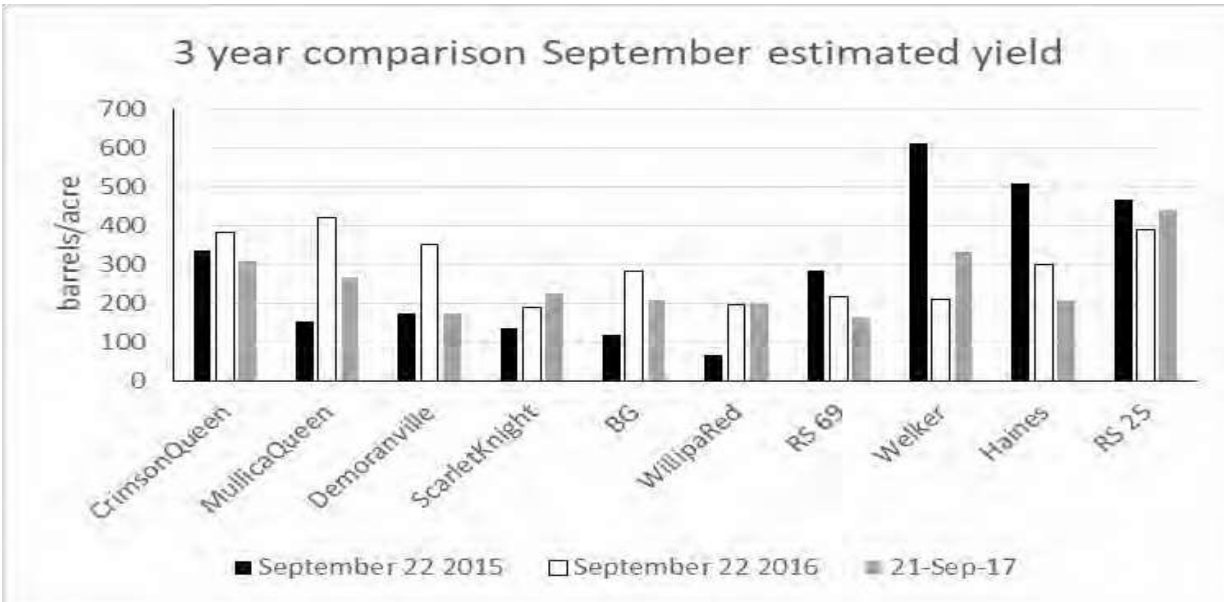

Figure 2. Comparison of estimated yields for 10 cranberry varieties grown at the BC Cranberry Research Farm, Bog 1. Each bar is an average, based on yield from three square-foot plots hand harvested from each variety in late September of each year.

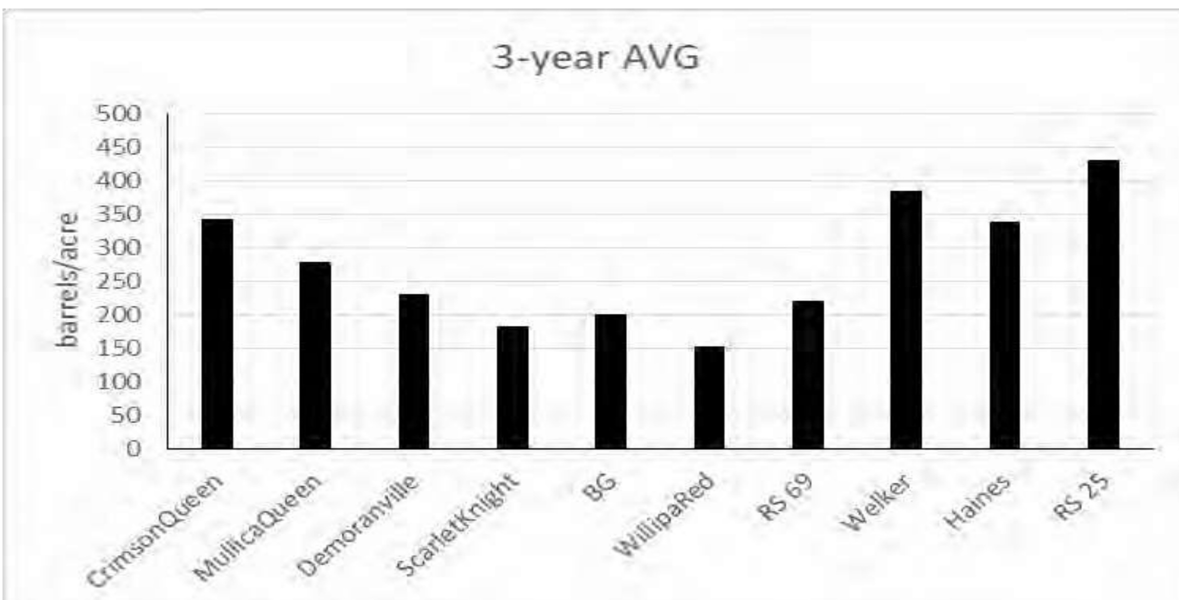

Figure 3. Average estimated yield for 10 cranberry varieties grown at the BC Cranberry Research Farm, Bog 1. Data are the averages of three square-foot samples collected from each variety in late September of three years (2015 to 2017).

One reason yields may have been lower in 2017 compared to the previous year for most of the varieties is because of nutritional status. The whole farm was fertilized on July 16 with 4-20-17; additional N was put on some plot based on the 2016 foliar nutrient data. Despite this, comparing foliar nutrient levels across all varieties in Bog 1 shows that levels for the important macronutrients nitrogen, calcium and magnesium were down from 2016 levels (Table 4a); micronutrient levels were also lower in 2017 than 2016. In addition, to nutrient levels being lower than the year before, in both years all varieties had nitrogen, phosphorous and potassium levels below the lowest normal concentration recommended for eastern North America (Davenport *et al.* 1995).

Table 4a. Foliar macronutrients for plots in Bog 1. Uprights were collected on August 26, 2016 (left columns) and August 25, 2017 (right columns) (Data courtesy of PSAI Inc., Richmond BC for both years)

	Nitrogen %		Phosphorus %		Calcium %		Magnesium %		Potassium %	
	16	17	16	17	16	17	16	17	16	17
Crimson Queen	0.84	0.72	0.07	0.06	2.25	1.45	0.34	0.23	0.31	0.39
CNJ99-9-25	0.96	0.85	0.08	0.07	2.00	1.32	0.29	0.23	0.28	0.33
Mullica Queen	0.79	0.68	0.06	0.06	1.65	0.78	0.39	0.23	0.21	0.32
Haines	0.68	0.72	0.07	0.07	1.80	1.19	0.29	0.25	0.26	0.38
Demoranville	0.64	0.62	0.06	0.06	1.65	1.19	0.29	0.22	0.30	0.38
Welker	0.62	0.66	0.06	0.06	1.75	1.19	0.32	0.25	0.26	0.34
Scarlet Knight	0.71	0.72	0.07	0.06	1.75	1.30	0.39	0.25	0.27	037
CNJ99-52-69	0.60	0.63	0.06	0.06	1.50	1.12	0.22	0.20	0.23	0.36
BG	0.77	0.58	0.06	0.07	1.20	0.93	0.27	0.21	0.26	0.36
Willipa Red	0.58	0.72	0.06	0.06	1.15	0.88	0.23	0.22	0.34	0.46

Table 4b. Foliar micronutrients for plots in Bog 1. Uprights were collected on August 26, 2016 (left columns) and August 25, 2017 (right columns) (Data courtesy of PSAI Inc., Richmond BC for both years)

	Copper (ppm)		Zinc (ppm)		Iron (ppm)		Manganese (ppm)		Boron (ppm)	
	16	17	16	17	16	17	16	17	16	17
Crimson Queen	3	2	31	30	135	119	208	155	41	34
CNJ99-9-25	3	5	30	32	155	147	215	137	47	40
Mullica Queen	3	4	32	24	125	124	138	66	52	44
Haines	3	4	25	26	130	98	88	101	38	41
Demoranville	3	2	28	26	145	124	100		40	35

Welker	2	3	27	24	135	83	93	90	47	39
Scarlet Knight	3	5	36	27	140	83	108	83	42	34
CNJ99-52-69	3	5	22	18	150	133	93	101	48	30
BG	2	5	22	32	160	114	125	114	55	36
Willipa Red	2	3	21	19	110	119	105	101	34	24

While yields may have been lower in 2017 for the majority of varieties, so was fruit rot. While levels of fruit rot are generally low at the BC Cranberry Research Farm, we observed <1% fruit rot, by weight, for most of the varieties (Fig. 4). BG was the variety with the highest levels of fruit rot in 2016 with an average of 14.57% fruit rot among the fruits hand-harvested from square-foot plots. We only observed an average of 3.27% rot for BG in 2017.

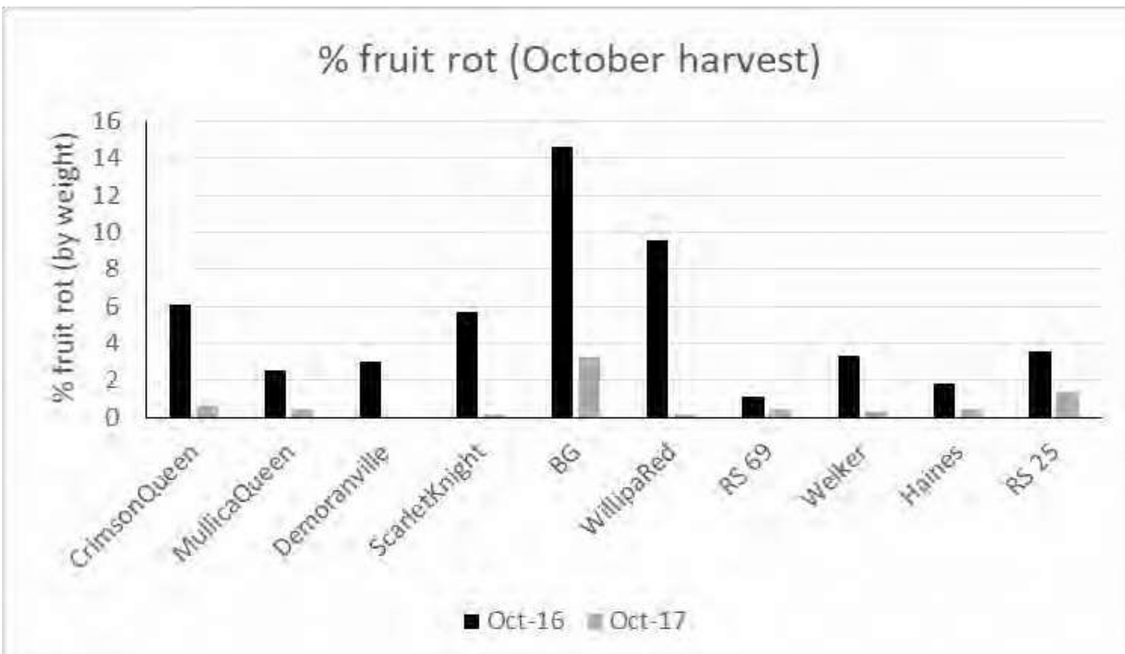

Figure 4. Comparison of fruit rot in hand-harvested berries from 1 square-foot plots from different cranberry varieties at the BC Cranberry Research Farm, Bog 1. Data are based on the average of three plots/variety and were collected in 2016 and 2017.

Bog 2 (Rutgers 2013) - Among the numbered varieties in the Rutgers 2013 plants, four releases have been identified as performing well in BC, with yields at approximately 300 barrels/acre or higher over the past three years (Fig. 5). These varieties – RS-11, 18, 71 and 155 – also have low levels of fruit rot (Fig. 6). Finally, these four varieties have shown promise because they develop colour more slowly, which makes them potential candidates for a late cranberry harvest. For example, on November 7, 2017 the TACY readings (an indicator of colour) were 96, 63, 37, and 26 for RS-155, 71, 18, and 11, respectively. Under the current Oceanspray incentive program these TACY readlings would have earned an additional $0.25 to 2.50/bbl for RS-71, 18 and 11. It is these types of nuanced marketing factors that create interesting opportunities for growers with newer varieties.

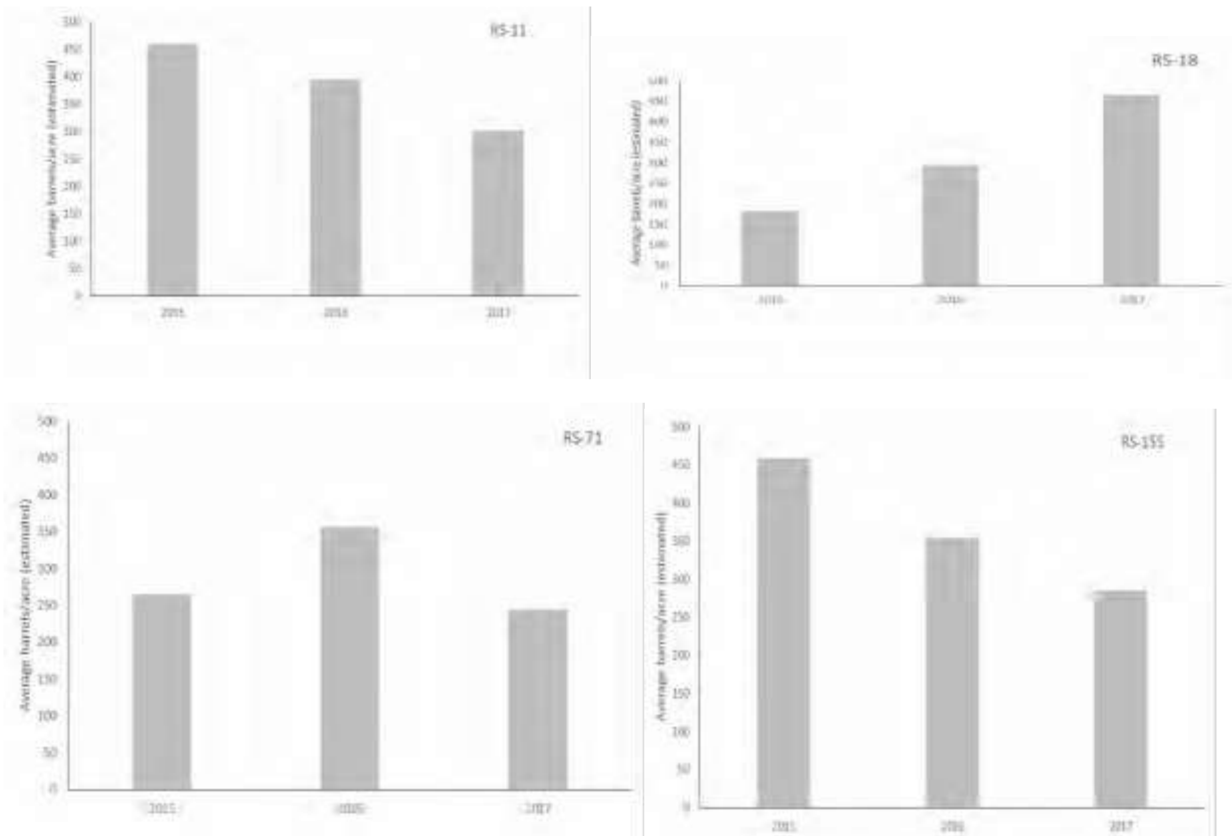

Figure 5. Comparison of estimated yields for four numbered cranberry varieties from the Rutger Breeding Program and grown at the BC Cranberry Research Farm, Bog 2. Each bar is an average, based on yield from four square-foot plots hand harvested from each variety in late September of each year.

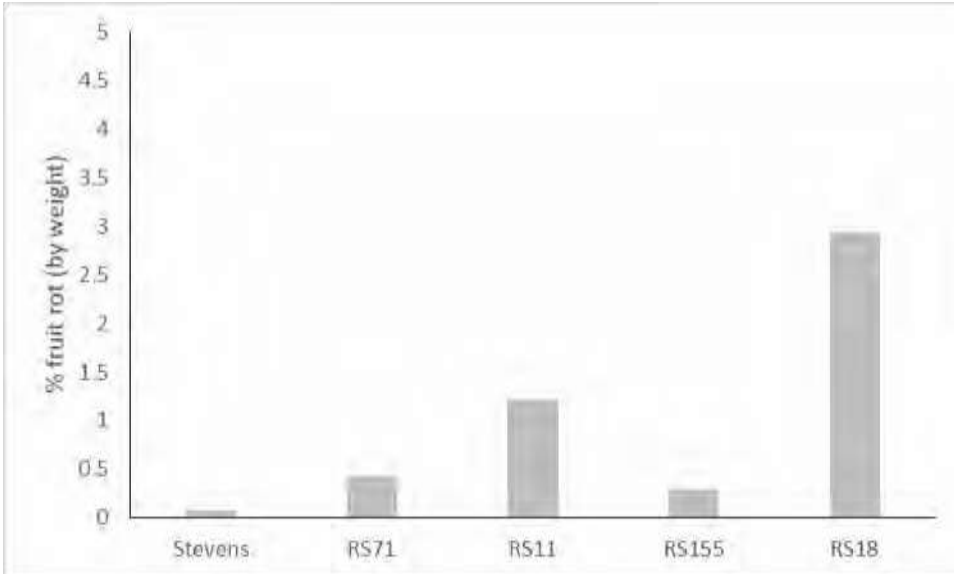

Figure 6. Comparison of fruit rot in hand-harvested berries from 1 square-foot plots from different cranberry varieties at the BC Cranberry Research Farm, Bog 2. Data are based on the average of four plots/variety and were collected in 2017.

Bog 2 (Valley Corporation 2014) - Among the five Valley Corp. varieties, there was a dramatic increase in yield among four of the varieties compared to 2016 (Fig. 7). Yield for Valley King – the best performing variety in 2016 – was down slightly, however Valley King was still the top Valley Corp. variety in 2017. The levels of rot amongst these varieties are below 5% (Fig. 8). One interesting, feature of the Midnight varieties is that they develop colour very early. For example, by August 25 they TACY score for the three midnight varieties was 28, 28, and 34 for Midnight 7, 8 and 11, respectively. These TACY values would have earned growers and additional $0.75 to 2.50/bbl in incentives. By October 18, however the Midnights were almost black. In contrast, Valley King and Pilgrim King had TACY scores of 42 and 48, which would have earned additional incentive payments of $2.50/bbl.

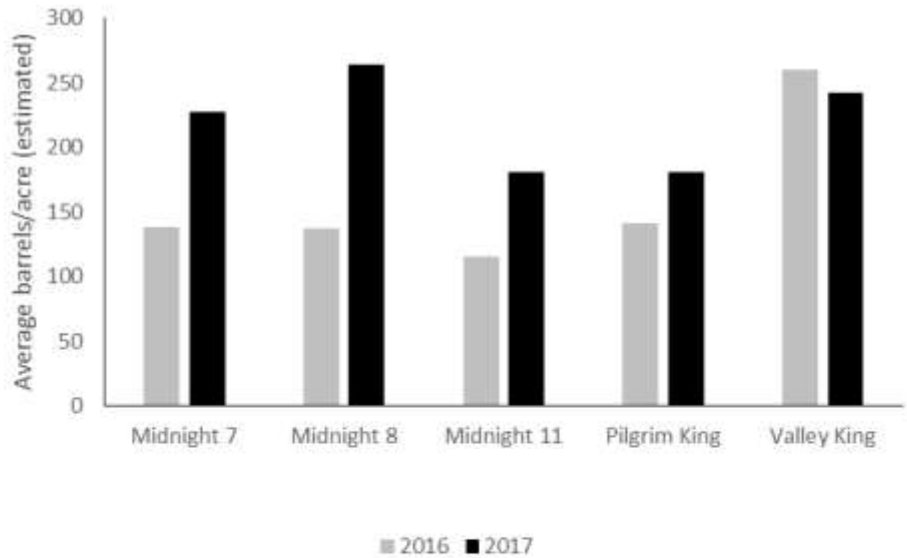

Figure 7. Comparison of estimated yields for five cranberry varieties from the Valley Corporaton breeding program and grown at the BC Cranberry Research Farm, Bog 2. Each bar is an average, based on yield from four square-foot plots hand harvested from each variety in late September of each year.

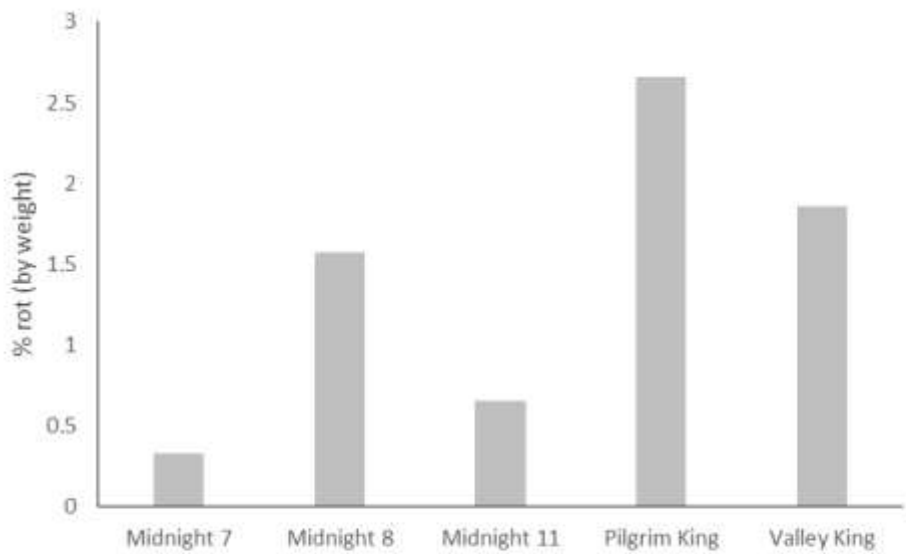

Figure 8. Comparison of fruit rot in hand-harvested berries from 1 square-foot plots from different cranberry varieties at the BC Cranberry Research Farm, Bog 2. Data are based on the average of four plots/variety and were collected in 2017.

Bog 2 (Rutgers 2015) - This was the first year of harvest for the 2015 Rutgers planting. There are 22 varieties planted in this area, including the released varieties Haines, Welker, Mullica Queen and a genetically pure (or true) planting of Stevens. Among the numbered varieties the four top varieties were RS3-11, 4-14, 20-30 and 20-13 with estimated yields of 250 barrels/acre. We did not do any additional analyses of these plots.

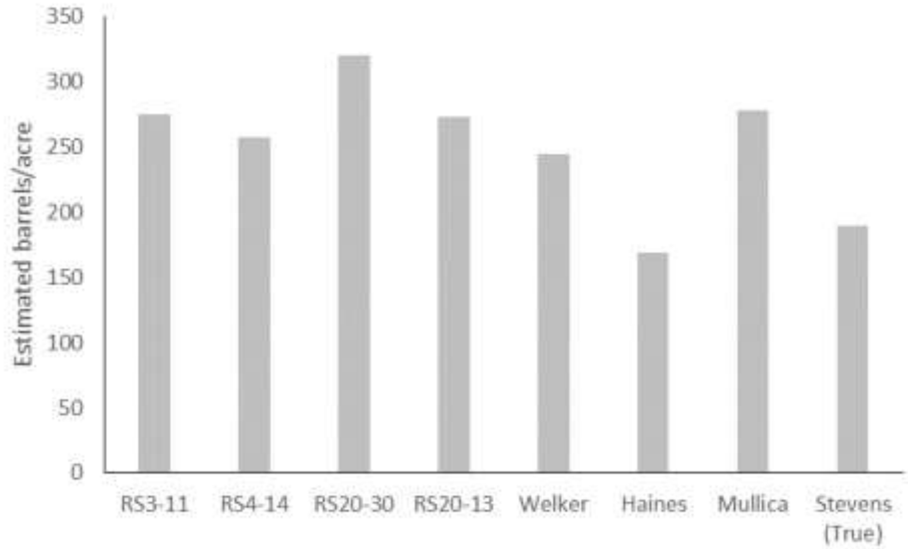

Figure 9. Comparison of estimated yields for four numbered and three released cranberry varieties from the Rutger Breeding Program and grown at the BC Cranberry Research Farm, Bog 2. Each bar is an average, based on yield from four square-foot plots hand harvested from each variety in late September of each year.

Variety Evaluation Next Steps: Based on the results of the past three years the following work is planned for 2018 at the research farm:

- Nutrient management plan for new varieties, possibly considering a nutrient management demonstration (need to do in consultation with breeders and cranberry physiologists in US)
- Plant RS11 in Bog 1, with Scarlet Knight being the variety that will most likely be replaced. This will allow us to monitor the establishment rate of RS11
- Continue to collect yield data on all released varieties and numbered varieties of interest in Bog 2 Rutgers 2013 and Valley Corporation 2014
- Continue to collect yield data on all varieties planted in the Bog 2 Rutgers 2015 block
- For the released and numbered varieties of interest we will take several smaller collections (250 g) of fruit at regular intervals during harvest (i.e. the earliest possible harvest date and the latest). The goal is to determine how the different

varieties perform in terms of the fruit quality parameters (Brix, TACY, firmness) which can generate additional payments in terms of Oceanspray incentives.

- Begin yield data collection on the Fruit Rot Resistant selections from Rutgers. These were planted in 2016 and will have their first harvest in 2018. This represents and additional 20 numbered varieties. Because these varieties have been bred specifically for Fruit Rot Resistance, we will also have to make observations and possibly collections of these plots during bloom – as this is when fruit rot pathogens begin the disease cycle.

PEST AND CROP MANAGEMENT DEMONSTRATION AND EFFICACY TRIALS

While variety evaluation is the main purpose of the BC Cranberry Research Farm, opportunities for evaluating pest and crop management inputs are also possible. These can be done either at the demonstration scale (minimal replication or no Control) or as more rigorously designed efficacy trial evaluations. In 2017, the following trials were conducted:

- Evaluation of a gibberellic acid product, reported to increase fruit set (efficacy)
- Evaluation of the herbicide sulfentrazone for moss control (efficacy)
- Continuation of fungicide evaluation for fruit rot management (demonstration)

Gibberellic Acid Evaluation for Increasing Fruit Set

Objective and Methods: The objective of this trial was to evaluate the efficacy of a gibberellic acid product (GS-4, GroSpurt Canada) in enhancing cranberry yield. The trial was conducted in the north end of Bog 3 on Mullica Queen. The trial consisted of four different GS-4 treatments: GS-4 @ 20 ppm applied one time, GS-4 @ 20 ppm applied two times, GS-4 @ 40 ppm applied one time and GS-4 @ 40 ppm applied two times. In addition there was a water only Control. The trial was set-up as a randomized block design with four blocks and each of the five treatments repeated one time, for a total of N=20 plots (Fig. 10). Plots were 1m^2 and were separated by a 2-m buffer on all sides.Treatments were randomly assigned to plots in each block. Treatments were applied on June 27, when the crop was at approximately 75% bloom, with the second applications occuring on July 11, 2-weeks later. GS-4 was diluted according to manufacturers instructions: 20 ppm treatments were prepared as 0.5 ml of GS-4 into 1-L of water and 40 ppm treatments as 1.0 mL of GS-4 into 1-L of water. We used a hand-pumped sprayers to treat each plot, which was sprayed to run-off (1-L). We observed plots for signs of phytotoxicity weekly, and for runner growth and yield on September 22. Yield data were based on the harvest of a single 1-square foot plot collected from the approximate centre of each treatment plot. Yield data were analyzed using one-way ANOVA as block effects were not statistically significant for any of the factors tested. Data were analyzed using JMP-In 5.1 (SAS Institute, Chicago, IL).

North

Control	**20 ppm applied 2X**	**40 ppm applied 2X**	**40 ppm applied 2X**
40 ppm applied 1X	**40 ppm applied 2X**	**20 ppm applied 1X**	**20 ppm applied 2X**
20 ppm applied 1X	**40 ppm applied 1X**	**Control**	**40 ppm applied 1X**
20 ppm applied 2X	**20 ppm applied 1X**	**40 ppm applied 1X**	**Control**
40 ppm applied 2X	**Control**	**20 ppm applied 2X**	**20 ppm applied 1X**

Figure 10. Plot layout for the gibberellic acid evaluation trial

Results: We did not observe any symptoms of phytotoxicity in any of the GS-4 treated plots. Nor did we observe any differences in runner growth. We did not observe a significant effect of GS-4 treatment on the estimated yield of marketable berries harvested from plots (Fig. 11; $F(4,15)=0.85$, $p=0.52$). We did see a significantly negative effect of GS-4 treatment on berry size, with treated berries being significantly smaller than the Control berries (Fig. 12; $F(4,15)=11.99$, $p=0.0001$). Finally, there was no difference in the number of marketable berries among the different treatments ($F(4,15)=2.35$, $p=0.10$). Devlin and Demoranville (1967), found that gibberellic acid increased the yield of cranberries on the variety Early Black, but also increased the number of small unmarketable fruit. In cherries gibberellic acid applications have been demonstrated to increase fruit size, colour and firmness (Canli and Orhan, 2009). However, the success of gibberellic applications on cherries is dependent on a number of factors including temperature (Rothwell and Pochubay, 2016).

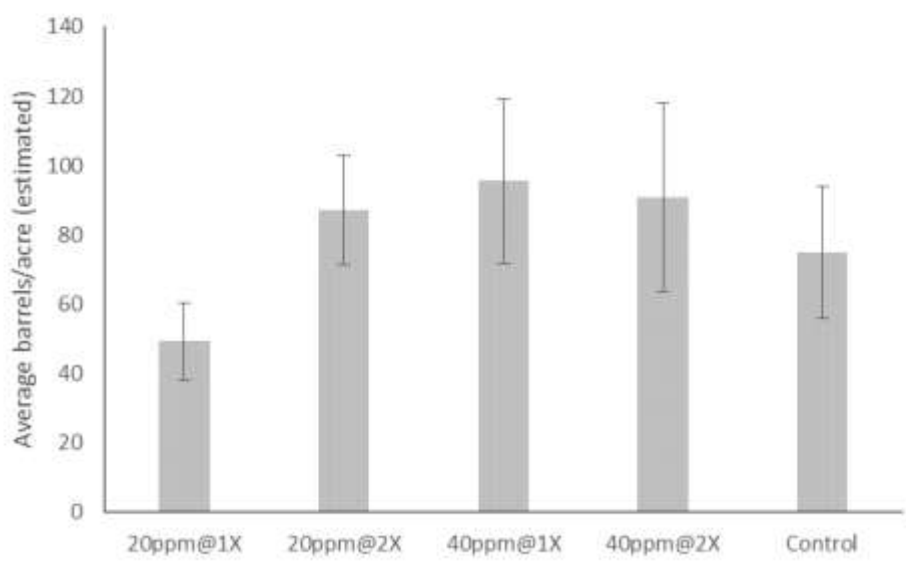

Figure 11. Effect of gibberellic treatments on estimated yield of Mullica Queen. Each bar is the mean ± s.e. of four replicates/treatment.

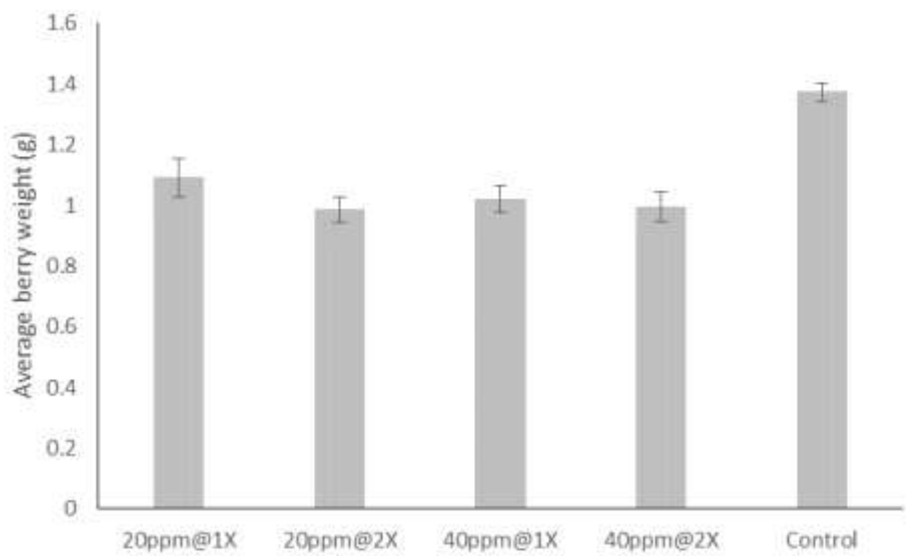

Figure 12. Effect of gibberellic treatments on the weight of cranberries. Each bar is the mean ± s.e. of four replicates/treatment.

Next Steps: The use of plant growth regulators and other inputs to enhance crop “immunity” are being marketed aggressively. However, it is not always clear if efficacy work has been done in cranberries. Cranberries are a complex crop and many factors such as soil, crop nutritional status, age of vines, and variety may all contribute to crop response (or lack of response) (Devlin and Demoranville, 1967). The research farm is an ideal environment to test different products and saves growers the risk crop injury. Such trials should continue with trials repeated on different varieties. For 2018, we recommend that the gibberellic acid trials be repeated in both Mullica Queen and at least one other variety. This would continue the work on gibberellic acid potential in cranberries as suggested by Devlin and Demoranville (1967).

Moss Control

Objective and Methods: Moss has recently been reported to be an increasing weed management issue for cranberries, especially in eastern North America (Ghantous and Sandler, 2017). In BC, while moss has not been identified as a priority weed compared to perennial grasses, sedges and horsetails it is nevertheless prevalent (Prasad, personal observation). Moss can be especially problematic in either newly planted bogs or in areas of bogs where vines coverage is poor. The moss is competing with the cranberries for space and if the coverage of moss is thick, will prevent the roots forming along the cranberry runners from making contact with the soil (REF). There are a number of different moss species that are prevalent in cranberry bogs (Ghantous and Sandler, 2017), but the exact species in BC bogs have not, to our knowledge been identified. The objective of our study was to examine the efficacy of the herbicide sulfentrazone (FMC Corporation) for moss control.

The trial was set up as a paired t-test, with 5 pairs of plots spread across the north end of Bog 4. Each pair of plots was set up in an area that had at least 50% moss cover and also some cranberry uprights present. Each plot was 1-m^2 and the two plots were separated by a 1-m buffer. The 5 pairs of plots were at least 3-m apart from each other. Plots were sprayed on April 27, 2017, when the uprights were in the tightbud phenologically. Sulfentrazone plots were sprayed with 0.08g/m^2 diluted into 2L of water applied with a backpack sprayer. Control plots were sprayed with 2L of water. Plots were checked on May 2 for indications of phytotoxicity and we did not observe any symptoms on either cranberries or moss. On July 18, we did a final assessment on moss cover in the plots, with data analyzed using t-test in JMP-In Version 5.1 (SAS Institute Chicago, IL).

Results: Sulfentrazone application did not result in a reduction in moss coverage when assessed approximately 6-weeks after treatment (Fig. 13; $t(8)=1.00$, $p=0.35$).

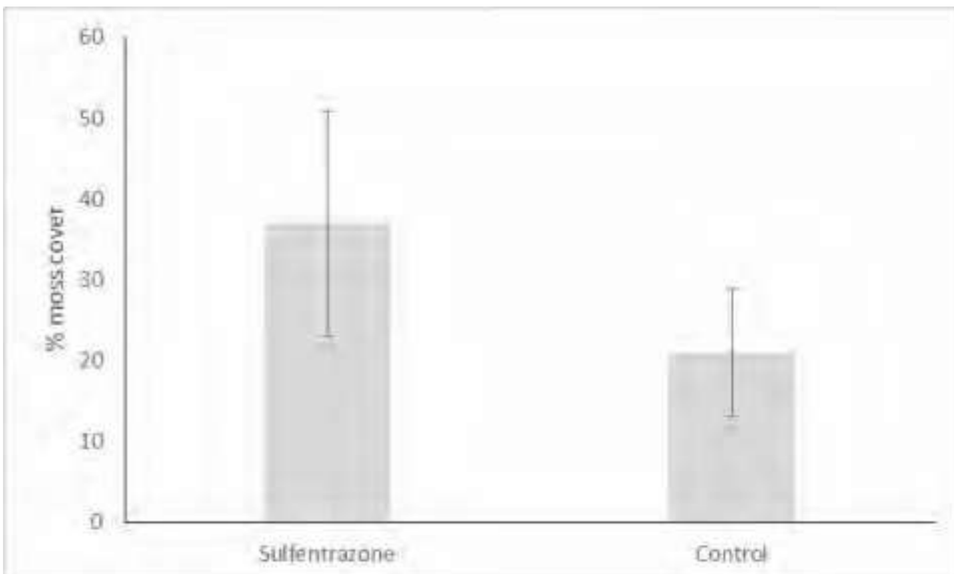

Figure 13. Effect of herbicide treatment on mean ± s.e. moss cover in five plots/treatment in a Stevens cranberry bed at the BC Cranberry Research Farm.

Next steps: In the US, sulfentrazone is registered for a number of other weeds that are common in cranberries and are present at the research farm including sedges and grasses. Trials should continue to examine early season herbicide applications with sulfentrazone. Additionally, work in the eastern US suggests that iron sulfate, and the herbicide flumioxazine could be effective for moss control (Ghantous and Sandler, 2017).

Fungicide Schedules for Fruit Rot Control

Objective and Methods: In 2017, we continued a fungicide demonstration trial that was started in 2016 in Bog 1. The methods were essentially the same over the two years. Treatments were the same as those used in 2016 (Table 5) and laid out in all 10 plots in

Bog 1 following the same pattern used in 2016 (Fig. 14). However, we assessed the efficacy of these combinations on reducing fruit rot in only seven of the varieties: Mullica Queen, Crimson Queen, Haines, and Welker. We took three 1-foot square samples of berries from each of the six treatment areas in these seven plots on October 6, 2017. Samples were processed in the same as for yield assessment. We compared rot levels for each variety among the six treatments. Berries were also examined for any indications of phytotoxicity such as discoloration or splitting. One major challenge of this work is that the overall levels of fruit rot at the cranberry research farm are quite low (see Fig. 4, 6, 8).

Table 5. Summary of fungicide treatments tested for fruit rot protection in Bog 1.

Treatment location (on map – Fig. 2)	**Fungicide Treatment**	**First Application: Product, Date and Method**	**Second Application: Product(s), Date and Method**	**Third Application: Product(s) Date and Method**
1, 4	Bravo+ Quadris +Quadris	Bravo, June 11 via Chemigation	Quadris, June 28, via boom sprayer	Quadris, July 5, via boom sprayer
2	Bravo	Bravo, June 11 via Chemigation	N/A	N/A
3	Bravo + Proline	Bravo, June 11 via Chemigation	Proline, June 28, via boom sprayer	Proline, July 5, via boom sprayer
5	Bravo + Quadris/Proline Tank Mix + Quadris/Proline Tank Mix	Bravo, June 11 via Chemigation	Quadris+Proline June 28 via boom sprayer	Quadris+Proline July 5 via boom sprayer
6	Bravo + Quadris/Proline Tank Mix	Bravo, June 11 via Chemigation	Quadris+Proline June 28 via boom sprayer	N/A

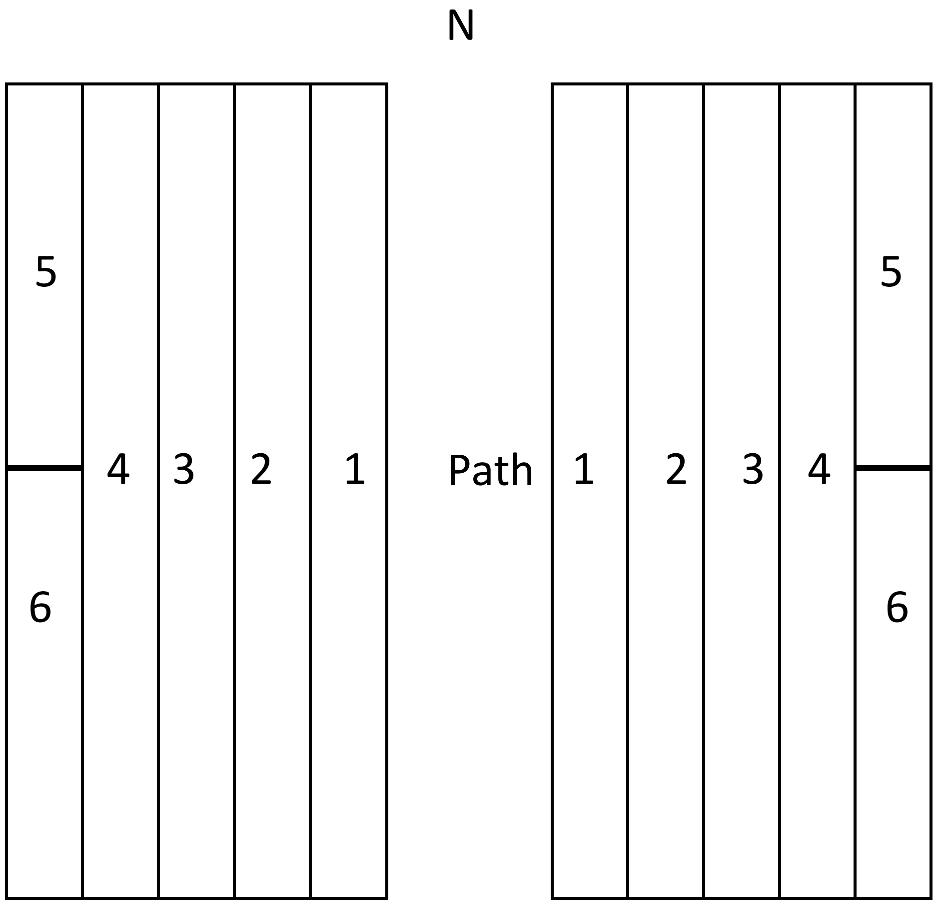

Figure 14. Layout of treatments for fungicide trial in Bog 1 (plots shown are East and West of the central path). Treatment layout was the same for each of the 10 plots in Bog 1. (See Table 5 for list of treatments).

Results: While overall levels of fruit rot were low in Haines and Welker plots (Fig. 15) we did observe higher levels of rot in Mullica Queen. For all four varieties the least amount of fruit rot was observed in the Bravo only treatment, i.e.the treatment with the least amount of fungicide. However, one problem with our demonstration trial is that we cannot separate a possible treatment effect from the effect of location. For example, the treatment with the highest level of rot in our demonstration – Mullica Queen with the Quadris + Proline combination, is located in the south-east edge of the bog, and gets heavy foot traffic as people comen in and out of the bog. Our visual assessment of fruit rot, may be in part capturing secondary rot initiated by mechanical damage due to heavy foot traffic in this area. In contrast, one reason why the Bravo plots, may have the least amount of rot is because they are away from edges and therefore get less foot traffic.

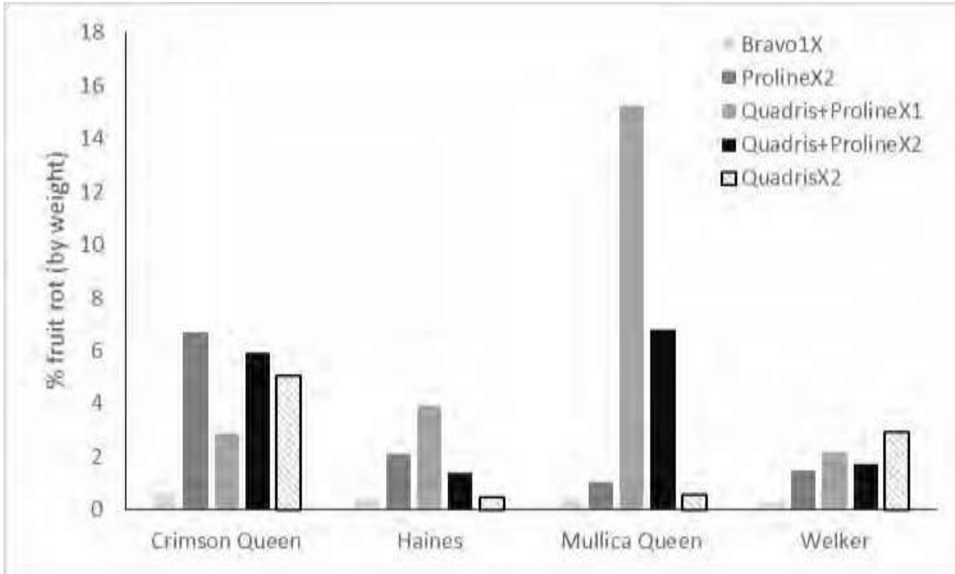

Figure 15. Comparison of fruit rot in four cranberry varieties treated with five different fungicide programs. Each bar represents the average rot in 3 1-ft^2 subsamples.

Next steps: To continue fungicide work at the cranberry research farm we should consider either inoculating plots or focusing on one or two varieties (e.g. Mullica Queen and Crimson Queen) and conducting the trial with replicated blocks across the varietal plots in order to control for variables such as mechanical damage due to location. As well, subsample of cranberries should be submitted for assessment of firmness.

Summary

The third year of yield data collection at the cranberry research farm was productive in terms identifying numbered varieties that may be candidates for release in western North America. These decisions by the breeder are based on the data and information collected from the BC Cranberry Research farm. The currently numbered varieties represent potential commercial varieties for 5 to 10 years from now. This will allow BC cranberry growers to remain competitive with both North American and global production. In addition, ensuring that the cranberry industry continues to explore new management tools for both current and future pest issues in an important function of the research farm. Moss is an example of a pest issue that will likely become worse with the predicted increase in shoulder season percipitation, due to climate change. As with varieties, have tools availabe for pest control, in anticipation of future needs, also helps BC cranberry growers remain competitive over the long term.

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